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STATUS OF SEMIOCHEMICALS RESEARCH IN MEALY BUG (HEMIPTERA: PSEUDOCOCCIDAE) MANAGEMENT

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ABSTRACT

Mealy bugs as invasive insects are well known as pest of a number of agricultural and horticultural crops in all tropical and subtropical regions of world. In order to check damage by mealy bugs, the farmers have become dependent on using organophosphates and synthetic pyrethroids. Due to wide host range and wax coated bodies, the mealy bugs are hard to control by insecticides. The injudicious use of insecticides has caused negative impact on naturally occurring biological agents like predators and parasitoids. Excessive use of chemicals, environmental pollution and health hazards have motivated researchers to work on development of alternatives to pesticides. The semiochemicals comprise of pheromones and kairomones. Use of semiochemicals is one such approach as they are safer and effectively used through monitoring, mass trapping, mating disruption and increasing parasitization. Hence, the paper is focused on the semiochemicals identified, synthesized and used against ten selected mealy bugs of family Pseudococcidae.

KEYWORDS: Pheromone, Kairomone, Semiochemical, Pseudococcidae, Parasitization, Biological Agent

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Original Article

INTRODUCTION

The mealy bug family (Hemiptera: Pseudococcidae) consists about 2240 species categorized into 300 genera (Millar, 2002). These are soft bodied small insects. They are phytophagous and feed on plant sap using their piercing and sucking type mouth parts. The bugs are recognized in field by white, mealy or powdery waxy secretion that covers its entire body (Franco et al., 2009). The waxes are secreted by lateral filaments on the body which are frequently seen in nymphal forms of males and females. The oviposition usually takes place inside a waxy pouch. In all species of the males are short lived and don't feed. It has been observed that some species of mealy bugs do cause considerable economic damage to agricultural and horticultural crops (McKenzie, 1967; Williams and Granara de Willink, 1992; Millar et al., 2002).

The following ten species of mealy bugs of pseudococcidae which cause heavy losses to crops are the subject of a review in this article:

- *Planococcus minor* (Maskell), the passionvine mealy bug is a serious pest on more than 250 host plants in Afrotropical, Austalasian, Neotropical and Oriental regions (Cox, 1989; Biswas and Ghosh, 2000).
- *Planococcus citri* (Risso) commonly known as citrus mealy bug causing damage to 65 species of plant belonging to 36 families (Ahmed and Abd-Rabou, 2010).
- *Planococcus kraunhiae* (Kuwana) commonly known as Japanese mealy bug. It is the pest of fruit trees

such as citrus, pears, grapes and persimmons (Oomasa 1990; Tsutsumi, 1997).

- *Planococcus ficus* (Signoret) commonly known as vine mealy bug having wide range of host plants apart from grapevine (Daane et al., 2008; Walton et al., 2009). It is a major pest of grapes attacking 16 families of plants. It is distributed in Afro tropical, Neotropic, Oriental, Paearctic region (Walton and Pringle, 2004).
- *Phenacoccus madeirensis* (Green) is commonly known maderia mealy bug. It is wide spread pest on ornamental plants both outdoor and in greenhouse. It is having 154 plant species belonging to 42 families. It is Neotropical in origin and now distributed in Afrotropical, Australasian, Nearctic, Neotropic and oriental regions (Pellizzari and Germain 2010; Kaydan et al., 2012, Williams, 2004).
- *Phenacoccus solenopsis* (Tinsley) commonly known as cotton mealy bug, is a major threat in many agricultural and horticultural crops of tropics and subtropics. The pest has been reported on 159 host species of plants in 31 families of plants worldwide (Wang, 2010; Arif et al., 2009; Prishanthini and Vinobaba, 2009)
- *Dysmicoccus grassii* (Leonardi) is widely distributed in Neotropics having many hosts like mango, pine apple, coffee, cacao and bananas (Williams and Granara de Willink, 1992; Matile-Ferrero and Williams, 1995).
- *Maconellicoccus hirsutus* (Green) commonly known as pink hibiscus mealy bug, is a native of South Asia spread to Africa and North America (Kairo et al., 2000). It is host to 76 families and 200 genera with preference to *Fabaceae*, *Malvaceae* and *Moraceae*. The insect prefers feeding on young stems, flowers and fruits (Mani, 1989; Vitullo et al., 2009).
- *Pseudococcus cryptus* (Hempel), cryptic mealy bug is pest of citrus orchards along with *P. citri*. It prefers feeding on leaves and twigs whereas *P. citri* concentrates on fruits only. *P. cryptus* is widely distributed in South East Asia, Tropical Africa, Mid Eastern Mediterranean and South America, having 90 host species (Holat et al., 2014).
- *Pseudococcus calceolariae* (Maskell), commonly known as citrophilus mealy bugs, having major impact on fruit crops (Zaviezo et al., 2010).

Damage of Mealy Bugs

All the above listed species of mealy bugs have very wide range of alternative hosts. They directly damage the plants by sucking sap and injecting toxins. They also cause indirect damage to their hosts by reducing photosynthesis due to development of sooty mold on viscous sugary secretions known as honeydew (deLemos and Sausa, 2006; AlAdawi et al., 2006). The feeding by the mealy bugs causes yellowing of leaves, dropping of fruits and flowers, wilting and defoliation of plants, reduced growth and death of plants. Three species of the mealy bugs, namely *P. citri*, *P. ficus* and *P. minor* are vectors of grapevine leaf roll virus, corky bark disease and banana streak virus respectively (Mukhopadhay, 2010; Rosciglione and Gugerli, 1989; Tanne et al., 1989, Arias et al., 2002). The occurrence of honeydew and sooty mold greatly reduces marketability of plant products.

Insecticides and their Impact on Natural Enemies of Mealy Bugs

To protect crops from mealy bug damage, the growers often use synthetic chemicals, like mevinphos, chlorpyrifos, imidacloprid and spirotetramat (Daane et al., 2006; Walton et al. 2004, Mansour et al., 2010a). The insecticides have shown limited effectiveness against mealy bugs due to protective waxy coating, their occurrence in

hidden plants parts and due to fast development of resistance to insecticides (Lentine et al., 2008; Prabhaker et al., 1997, Zhao et al., 2000). Due to limited effectiveness of insecticides against pests, the farmers were enforced to use higher doses and frequency of sprays. The vigorous high doses of insecticides are hazardous to environment and various non target beneficial insects (pollinators and natural enemies). It is well accepted fact that the non recommended use of pesticides against mealy bug has increased the pest densities and secondary pest outbreaks (leVieux and Malan, 2012). The adverse impact of high doses of insecticides on natural enemies life span, their fecundity and ability to locate hosts have been reported (Nas, 2004; Aktar et al., 2009; Wakgari and Gilimee, 2003; Desneux et al., 2007). The natural enemies of all the ten mealy bug species comprising of predators belong Coccinellidae (Coleoptera), Chrysopidae (Neuroptera), Cecidomyiidae(Diptera), Noctuidae and Oecophoridae (Lepidoptera) whereas their parasitioids belong to Encyrtidae and Aphelinidae (Hymenoptera) (Berlinger, 1977; Blumberg et al., 1999; Francis et al., 2012; Ahmed and Abd-rabou, 2010, Afifi et al., 2010). Mansour et al., (2011) found that chlopyrifos-methyl was the most toxic insecticide showing 100% mortality of *Anagyrus* sp. within 24 hrs of spray. Golmohammadi et al., (2009) also found that the imidacloprid was most toxic against 5th instar larvae of *Chrysoperla carnea* under laboratory conditions. Use of broad spectrum insecticides like chloropyrifos also caused adverse effect on the natural enemies such as *Coccidoxenoides peregrinus* (Timberlake) (Hymenoptera: Encyrtidae) of *P. ficus* (Walton and Pringle, 1999). In South Africa too, use of contact insecticides like Synthetic pyrethrin (Cypermethrin) and Carbamate (Mancozeb) against Vine mealy bugs showed adverse effect on the development of parasitoids *Anagyrus sp*. and *Coccidoxenoides perminutus* (Mgocheki and Addison, 2009). The awareness on harmful effects of insecticides on natural enemies has revealed that using chemicals has become a less desirable option to combat mealy bugs. The results further encourage adopting to biorational alternatives (use of semiochemical) to reduce the load of pesticides (Khater, 2011).

Semiochemical (Pheromone and Kairomone)

Term ‘Semiochemicals’ has been in used since 1971 and was derived from greek word “Semeon” meaning there by a “sign” or “signal”. It is an organic compound that transmits chemical messages and is used for intra and interspecies communication. The insects with the help of olfactory receptors present on antennae detect these semiochemicals directly from air. On the basis of effects produced by the semiochemicals, they are divided into two main categories: pheromones and allelochemicals (having kariomones) (Blun, 1996).

Term "pheromone" is derived from Greek word *pherein* (to transport) and *hormone* (to stimulate). The term was introduced by Karlson and Lüscher (1959). Pheromones are ecto-hormones secreted outside the body by exocrine glands which h affect the behavior of the receiver. On the base of functions, the pheromones are divided into the following categories (Cork, 2004; Lamprecht et al., 2008; Mostafa et al., 2012):

- Aggregation pheromones: compounds that increase the concentration of insects at the pheromone source.
- Alarm pheromones: compounds that stimulate insects' escape or defence behaviour.
- Sex pheromones: compounds that help individuals of the opposite sex to find each other.
- Trail pheromones: among social insects, compounds used by workers to mark the way to a food source, for example.

The kairomones are a class of chemical compounds which are advantageous to the receiver insects. These chemicals prove beneficial for many predators through guiding them to their prey or potential host insects. These semiochemicals or active compounds are isolated, identified and synthesised by using many sophisticated instruments like NMR, GC-MS, HPLC-MS, SPME and electrophysiological devices (Norin, 2007). They are used for monitoring, mass trapping and for feeding deterrents by killing, trapping and attracting pest insects (Rosell, et al., 2008; Heuskin et al., 2011). Some parasitoids are attracted to the sex pheromones and act as kairomones (Franco et al., 2008). The semiochemicals have several advantage over conventional insecticides. The present review aims to highlighting the active compounds identified, synthesised and their role in controlling the population of selected mealy bugs.

In *M. hirsutus* the volatile extracts isolated from females are further identified as 2, 2, dimethyl-isopropenyl cyclobutane methyl ester and Macanelliyl 2- methyl butanoate, also known as maconelliol (unsual terpenens) compound. The compound acts for attraction of males and used as sex pheromone (Zang et al., 2004, 2005). Gonzalez-gaona et al., (2010) demonstrated that female sex pheromone developed by Zang et al. 2004 and consisting of mixture of lavandulyl and maconellyl in 1:5 ratio significantly attracted males into traps proving useful in monitoring its distribution. Arai (2000) from Japan found the evidence of sex attractant from female volatile extract which attracts males of *P. cryptus* using behavior bioassay. This was identified as 3-isopropenyl-2, 2-dimethylcyclobutylmethyl 3-methyl-3-butenoate compound (Arai, et. al. 2003). It was further synthesized using NMR and MS from (+) - alpha-pinene and was used in mass trapping insects (Nakenata et al. 2003). Sugie et al., (2008) from Japan identified 2-isopropyliden- 5me-4-hexenyl butyrate as sex attractant component from *P. kraunhiae* which is known to be pest of fruit trees, like pear, citrus, grapes and persimmon. The attractant is further used as matting disrupter which destroys the orientation of the males (Teshiba et al., 2009). Chrysanthemyl 2- acetoxy,3-methylbutanoate was isolated and identified as sex pheromone from *P. calceolariae* which is major pest of citrus, grapes, sugarcane and apple (El-Sayed et al., 2010). The pheromone was further configured as R, R, R,-chyrsanthenyl 2 acetoxy-3-methylbutanoate (Unelius et al., 2011). The evidence for the presence of sex pheromone of *P. citri* was recorded by simple bioassay. More males are attracted to female extract (Rptundo and Tremblay, 1976). The attractant was later identified as (1 R-cis) - (+)-2, 2-dimethyl-3- (1 methylethenyl) cyclobutanemethaol acetate (Bierl-leonhardt et al., 1981) and was used as sex pheromone after its synthesisation (Linda et al. 2004). The sex pheromone found in *D. grassii*, was identified as (-)-(R)-lavandulyl propionate and acetate (de Alfonso, 2012). Two components, from aeration extracts of virgin females of madeira mealy bug, *P. madeirensis* were identified as trans-(1R, 3 R)-chrysanthemyl (R)-2-methylbutanoate and (R)-lavandulyl (R)-2-methylbutanoate (with a ratio of 3:1) and used as sex pheromone (Ho et al., 2009). The pheromone is used in the monitoring of mealy bug population to know the proper timing of control measures of mealy bugs (Song et al., 2012). The presence of semiochemicals in the *P. solenopsis* was reported by using behavior assay, where the female volatile extracts attracted the males (Singh and Kumar, 2015). The sex pheromone of the mealy bug, *P. minor* was isolated by fractionalization of crude extract obtained by aeration of virgin females. The pheromone was identified as the irregular terpenoid, 2-isopropyl-5-methyl-2, 4-hexadienyl acetate (Ho et al., 2007). Another sex pheromone of *P. ficus* has recently identified as (s)-(+)-lavandulyl senecioate and commercially produced in its racemic form (Hinken et al. 2001). It was developed and optimized for monitoring of the population of mealy bugs. This sex pheromone also has kairomonal activity of attracting *Anagyrus pseudococci* (Millar et al. 2002). The parasitization activity of *Anagyrus sp.* Increased with installation of mating disruption in vineyards (Cocco et al. 2014, Walton, et. al. 2006, Mansour et al., 2010b).

CONCLUSIONS

Development of biorational approaches like semiochemicals (pheromones and kairomones) are way more productive alternatives to conventional pesticides. The semiochemicals do not show any hazards to environmental, non target living organisms and resistance against them. The compounds are in use to killing, trapping and disrupting the mating behaviour of mealy bugs. When the semiochemical (kairomone) is used together with a mating disruptor can increase the parasitization on mealy bugs. The use of the semiochemical integrated with other control measures in integrated pest management program can provide more productive and reliable result, increasing thereby the crop yields. Therefore, to promote eco-friendly pest management in mealy bugs consistent research efforts are required in the identification of semiochemicals.

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